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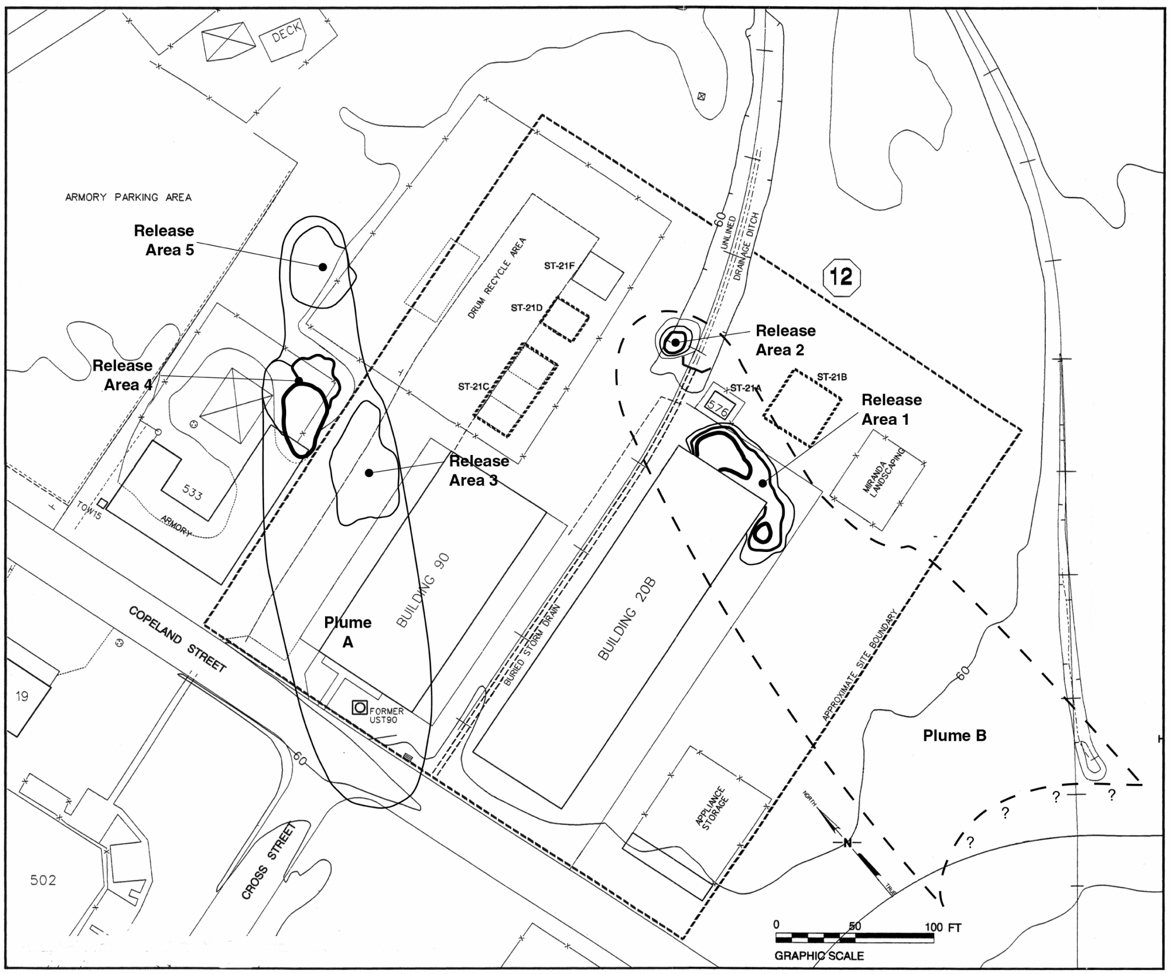
Dynamic Field Activity Case Study:
Soil and Groundwater Characterization, Marine Corps Air Station Tustin



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Notice

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Abbreviations

ARAR	applicable and relevant or appropriate requirement
bgs	below ground surface
BRAC	Base Realignment & Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DNAPL	dense non-aqueous phase liquids
DP	direct push
DQO	data quality objective
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
ESI	expanded site inspection
FAM	field-based analytical method
FID	flame ionization detector
ft	foot
GC	gas chromatograph
gpd	gallons per day
gpm	gallons per minute
IRP	Installation Restoration Program
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
μg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NPL	National Priorities List
PAH	polyaromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCOC	potential chemicals of concern
PID	photoionization detector
QAPP	quality assurance project plan
RI/FS	remedial investigation/feasibility study
SWMU	solid waste management unit
TCE	trichloroethene
TDS	total dissolved solids
TRPH	total recoverable petroleum hydrocarbons
UST	underground storage tank
VOC	volatile organic compound

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Abstract

The Navy used a dynamic field activity (i.e., a project that combines on-site data generation with on-site decision making) for a CERCLA remedial investigation (RI) at the Marine Corps Air Station (MCAS) Tustin between 1995 and 1996. Field-based analytical methods (FAMs) provided defensible data that met project objectives for delineating the nature and extent of contamination in the base-wide soil, surface water, and groundwater investigations. The FAMs were also used to choose monitoring well locations and select a subset of risk assessment samples for off-site analysis. At one location on the base, the dynamic field activity saved the Navy over 15 percent of the total site cost of the investigation and helped to compress the investigation schedule by an estimated 60 percent.

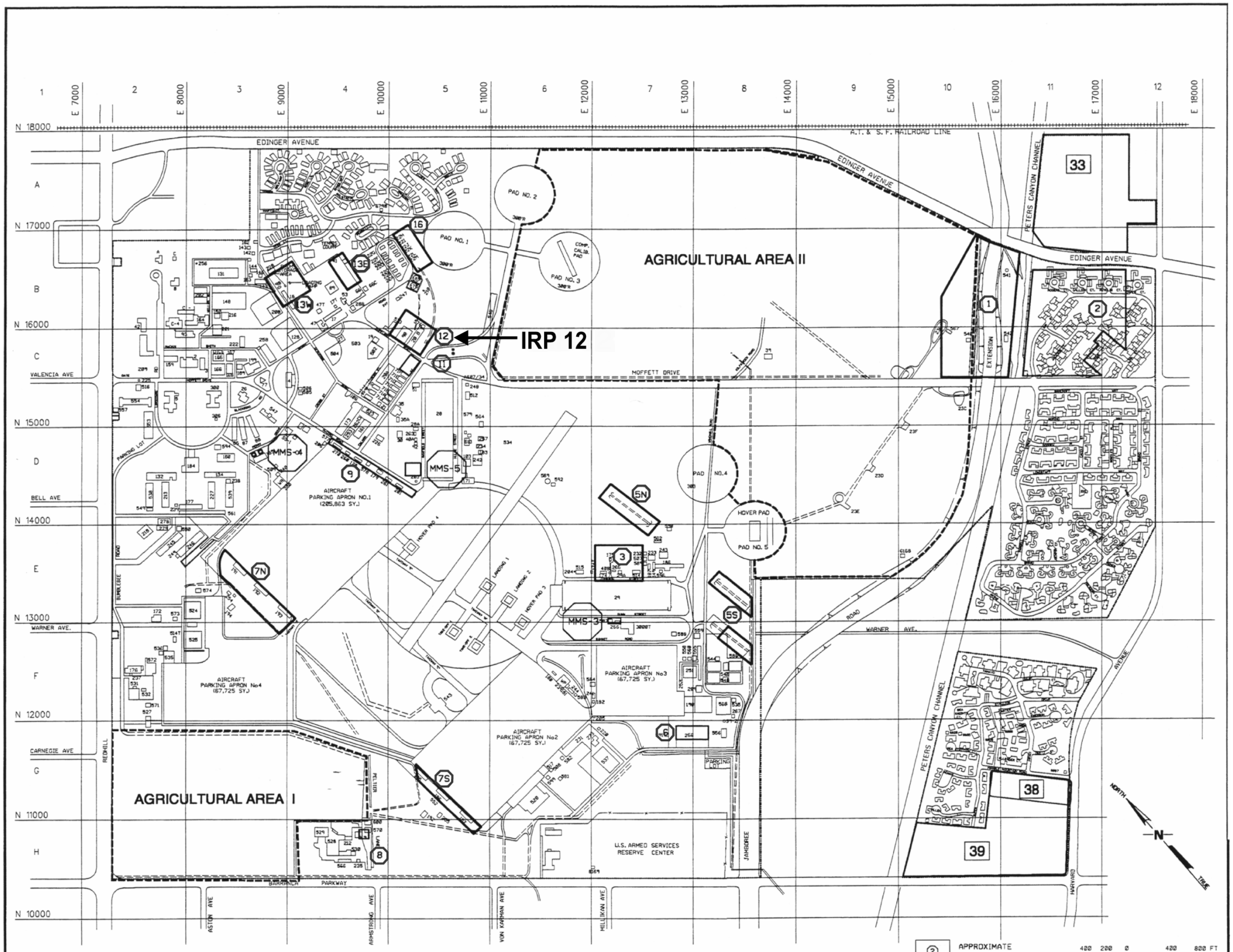
Background

The Navy planned, implemented, and completed a dynamic field activity at MCAS Tustin, in southern California, between July 1995 and June 1996. The 1,600-acre base was part of the Department of Defense's Base Realignment and Closure (BRAC) program, which designated the land for redevelopment and integration into the surrounding community of Tustin, located just north of Irvine in Orange County. The dynamic field activity at the site demonstrated cost savings of $90,000, a temporal savings of several years, and regulator satisfaction with the on-site decision-making process. A map of the entire site is presented in Exhibit 1.

The Navy conducted a preliminary assessment and an expanded site inspection (ESI) between 1991 and 1993 at all areas with documented releases. Although the site had not yet been included on the National Priorities List (NPL) at the beginning of the CERCLA remedial investigation/feasibility study (RI/FS), regulators had already collected all of the required data. If EPA had determined that Superfund remedial funds were necessary, the site could have been listed quickly on the NPL. The regulatory authorities involved in the dynamic field activity were the California Department of Toxic Substances Control, the California Regional Water Board, and EPA Region 9. Representatives of these groups, along with the Navy and their contractor, made up the BRAC Cleanup Team. Cooperation among these stakeholders was vital for the success of the investigation.

Based on background information, the BRAC Cleanup Team documented 15 separate areas with hazardous substance releases. They designated these areas for further investigation and named them Installation Restoration Program (IRP) sites. Because they believed seven of these IRP sites had substantial releases, they placed them in the remedial program. The BRAC

Exhibit 1
Marine Corps Air Station Tustin Map Showing IRP Sites



Adapted From: MCAS Tustin Remedial Investigation Report

Cleanup Team planned Engineering Evaluation/Cost Analyses (EE/CAs) at the remaining eight IRPs, with the stipulation that if the contamination was worse than anticipated, they would transfer the sites to the remedial program. In addition to these 15 IRP sites, the Navy was responsible for investigating:

- Approximately 70 solid waste management units (SWMUs) that had operated under RCRA authority;
- Several underground storage tanks (USTs), including heating oil tanks and on-base gasoline facilities;
- Several underground jet-fuel lines;
- Agricultural fields to determine if there was any lasting impact due to pesticide application; and
- Base residential areas in order to confirm and formally declare that no further response was required.

During preliminary discussions among BRAC Cleanup Team members, the Navy contractor suggested that the investigation could be carried out faster and cheaper if a dynamic approach with FAMs was used. Once this approach was accepted by the BRAC Cleanup Team, the investigators developed a plan to complete the field work in a single mobilization. This plan would let them integrate the work at all of the contaminated sites so that they could benefit from the economies of scale by moving between locations as equipment and personnel were needed. For the purposes of providing a succinct case study of how dynamic field activities can be conducted for a CERCLA RI/FS, this discussion focuses exclusively on the investigation of only one site: IRP-12, Drum Storage Area No. 2. The field team required a total of only six weeks at IRP-12; however, they worked on the site intermittently over the ten months of the entire base investigation.

Using a Systematic Planning Process

Investigators used the EPA's seven-step data quality objective (DQO) process (U.S. EPA, 1994a) to guide the planning, and they based their decisions on information available from earlier studies. The systematic planning process included the following information:

- Reviewing existing site information;
- Selecting key personnel;
- Identifying the project objectives;
- Developing a conceptual site model;
- Preparing sampling and measurement strategies; and
- Selecting appropriate analytical methods, equipment, and contractors.

By following the steps laid out in EPA's guidance, they developed DQOs that were reviewed and approved by EPA Region 9. These DQOs can be reviewed on EPA's web site at: http://www.epa.gov/superfund/programs/dfa/casestudies.

Reviewing Existing Site Information

Investigators reviewed existing data and found that the 2.5 acre IRP-12 site had been used as a drum storage area from the mid-1960s until July 1975. Records indicated that these drums contained new and spent solvents, used motor oil, and hydraulic fluids. There were three reported releases in three separate drum storage areas, ranging in quantity from 600 to 1,000 gallons. In addition, previous investigations indicated that trichloroethene (TCE) had contaminated groundwater and polyaromatic hydrocarbons (PAHs) had been released in a drainage ditch that ran through the site. Exhibit 2 provides the location and concentration of contamination discovered during the ESI. This field work also found that the upper 15 to 20 feet of soil was a silty clay. The next 5 to10 feet was a silty sand.

Selecting Key Personnel

As is necessary for the successful execution of dynamic field activities, the contractor's planning team members were very qualified and experienced in their areas of responsibility. Team members and their backgrounds included:

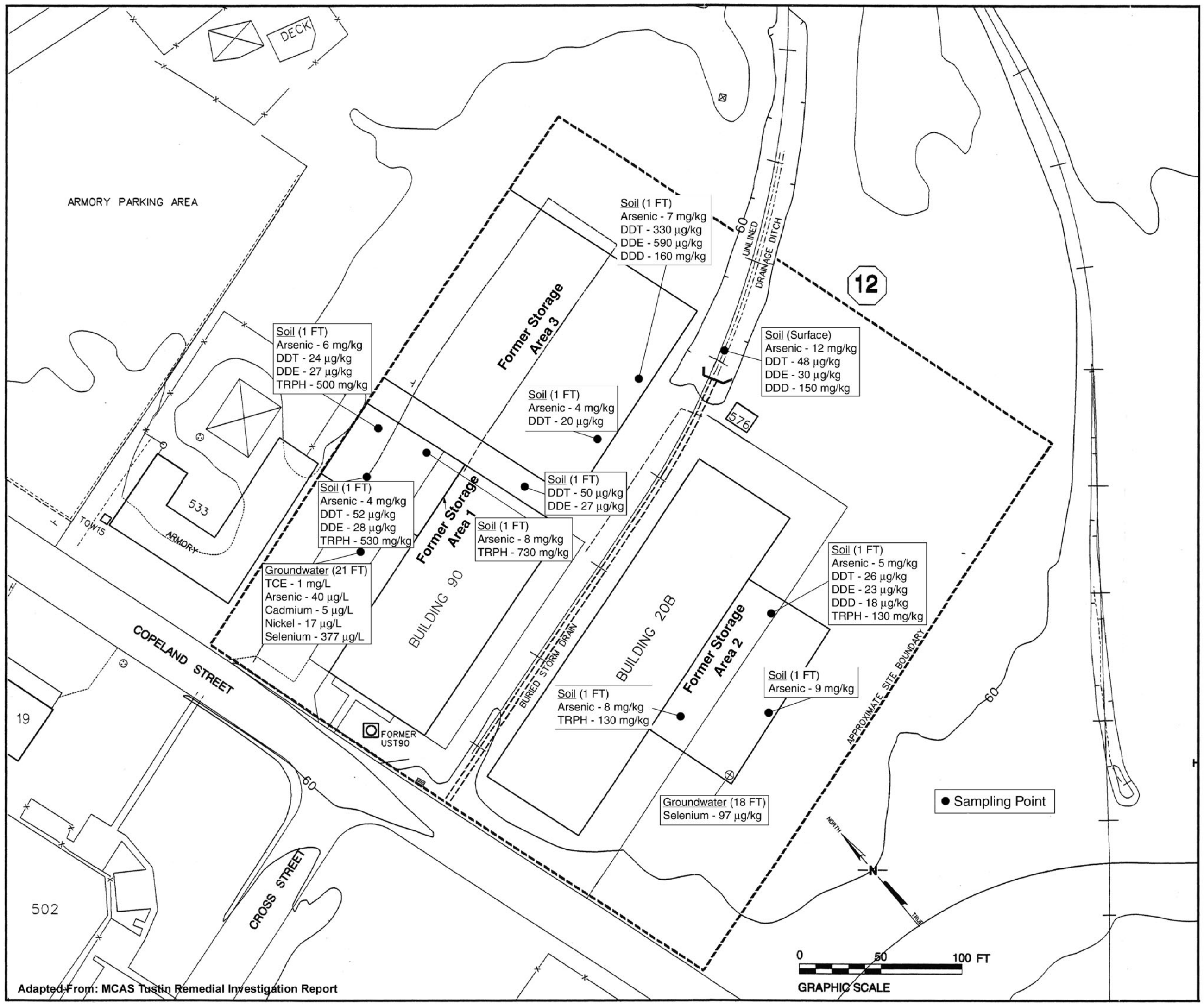
- Project manager: A civil engineer with over 20 years of engineering and management experience. His primary functions were client relations, program office interactions, management oversight of the activities, and ensuring that adequate resources were available to the investigation teams.

- Technical team leader: The technical team leader was cross-trained in hydrogeology, chemistry, and chemical fate and transport. He had more than 15 years of experience in site investigations and generally was in the field full-time. He had authority over the field team members' activities, and he was responsible for providing recommendations to the Navy and regulators.

- Project chemist: Two project chemists took part in the initial planning of the investigations and were available throughout the project for consultations. Each had more than 20 years of experience in analytical chemistry and QA/QC.

- Project hydrogeologist: The project hydrogeologist was involved in the planning and implementation of the investigation. Although he worked on this project full-time, he was based at the home office. Geologic information was faxed to him on a regular basis so that he could analyze the data and provide advice to the technical team leader. He also was available for meetings on an "as needed" basis and was on site at times when the

Exhibit 2
Distribution of Contaminants Above Screening Levels Discovered During Expanded Site Inspection



technical team leader determined his presence was required. He had PhDs in geotechnical engineering and geology as well as more than 10 years of experience.

- Risk assessor: A risk assessor was involved in the initial planning and was responsible for producing the baseline risk assessment document. He held a PhD in toxicology, had more than 20 years experience in risk assessment, and was available to the project on an "as needed" basis.

- Data management: A data manager worked full time on the project. She had more than 10 years experience in environmental work and held a PhD in geostatistics.

- Community involvement: A community involvement specialist with more than 10 years experience was involved in the planning stages and was responsible for all aspects of community involvement. She worked part-time for the project and was available on an "as needed" basis.

At full strength, the base field team for the entire site also consisted of seven geologists of varying experience (1-7 years), associated field technicians also of varying experience (0– 3 years), two chemists for the mobile laboratory (each with more than 10 years experience), a site supervisor, and a part-time health and safety officer.

Identifying the Project Objectives

The DQO process produced five principal study questions for IRP-12 that the investigation sought to answer:

- Do the analytical results from the ESI indicate widespread PAH contamination of the drainage ditch, and is there any vertical migration?
- Are there any direct release areas containing high concentrations of contaminants (i.e., hot spots) in the soils of the three storage areas?
- Has there been any vertical migration of contaminants from the three storage areas?
- What is the lateral and vertical extent of the TCE contamination in the groundwater, and what is its source?
- Have any of the four SWMUs found on IRP-12 released any hazardous materials to the soil?

Developing a Conceptual Site Model

Based on the existing information, the project planners developed a preliminary conceptual site model with the following scenario: waste oils (containing PAHs and metals) and solvents (primarily TCE laden with metals from paint stripping) were released from the drum storage area 20 to 30 years earlier, either through decay of the drums or by spillage during filling and handling. Because the soils on the site are alkaline with low permeability, the contaminants migrated slowly into the soil to form a secondary release source. The groundwater had been impacted in at least one area of the site, but the source was unknown. In addition, depending on the quantity of releases, groundwater in other areas of the site may have been impacted.

Additional aspects of the initial conceptual site model included the following points:

- The water table at the site would be 7 feet below ground surface (bgs) (based on information from a nearby UST site and another nearby investigation);
- Movement of contaminants in the groundwater would be very slow in the silty clay and somewhat more rapid in the silty sand;
- The 1,000 μg/L TCE concentration in a monitoring well near Building 90, with no known source, required an up gradient investigation; and
- The site was sufficiently close to the fuel farm to assume that groundwater at IRP-12 also moved in a south-southwesterly direction.

Exhibits 3 and 4 provide the initial conceptual site model of IRP-12, and Exhibit 5 provides the initial exposure model.

Exhibit 3
Initial Conceptual Site Model Pictorial for IRP-12

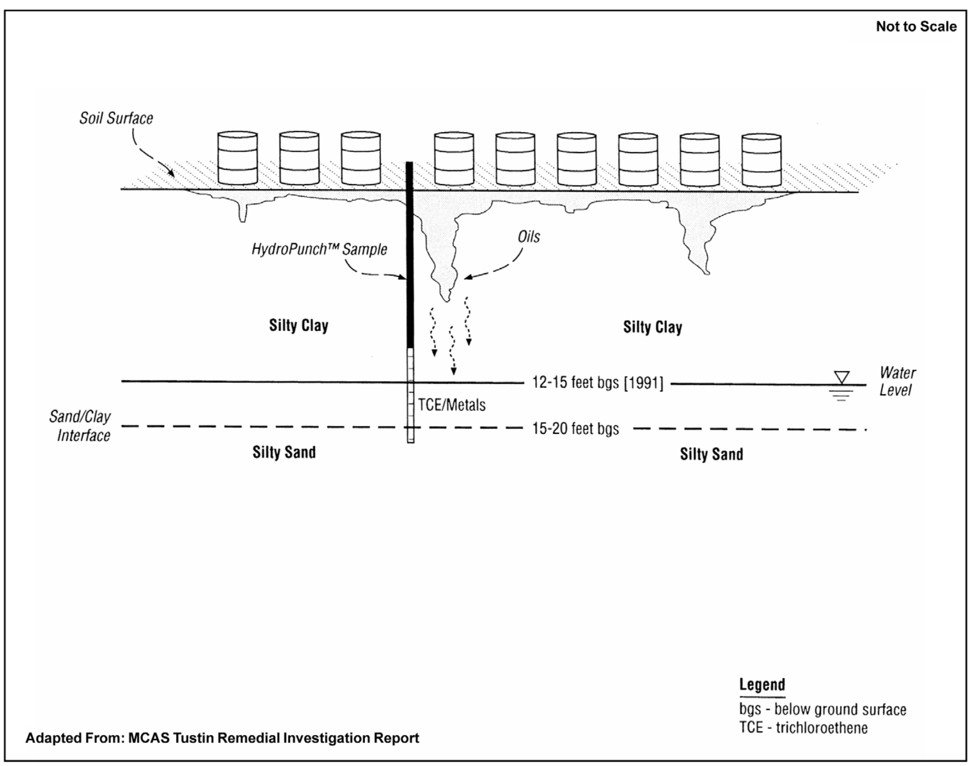
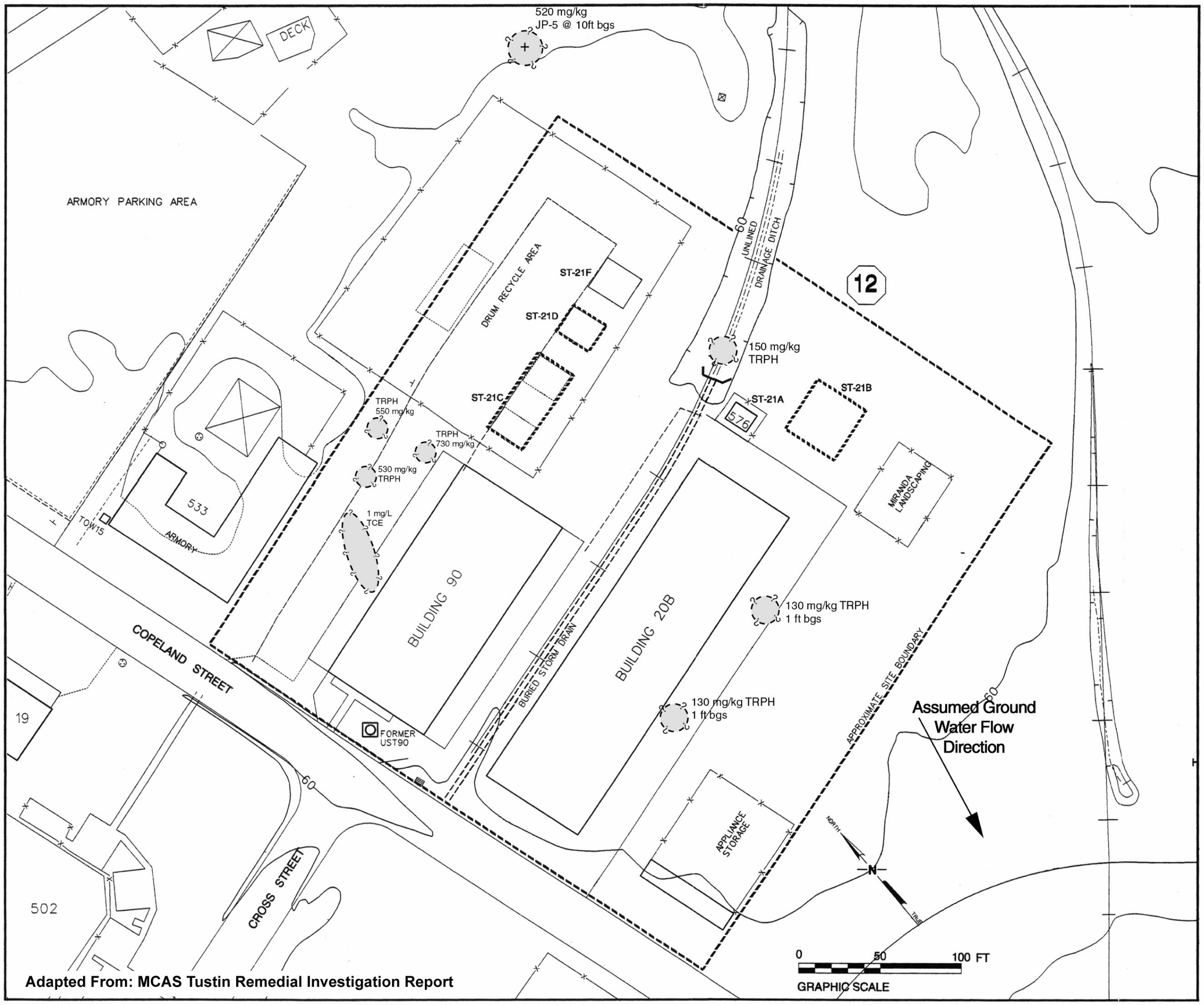
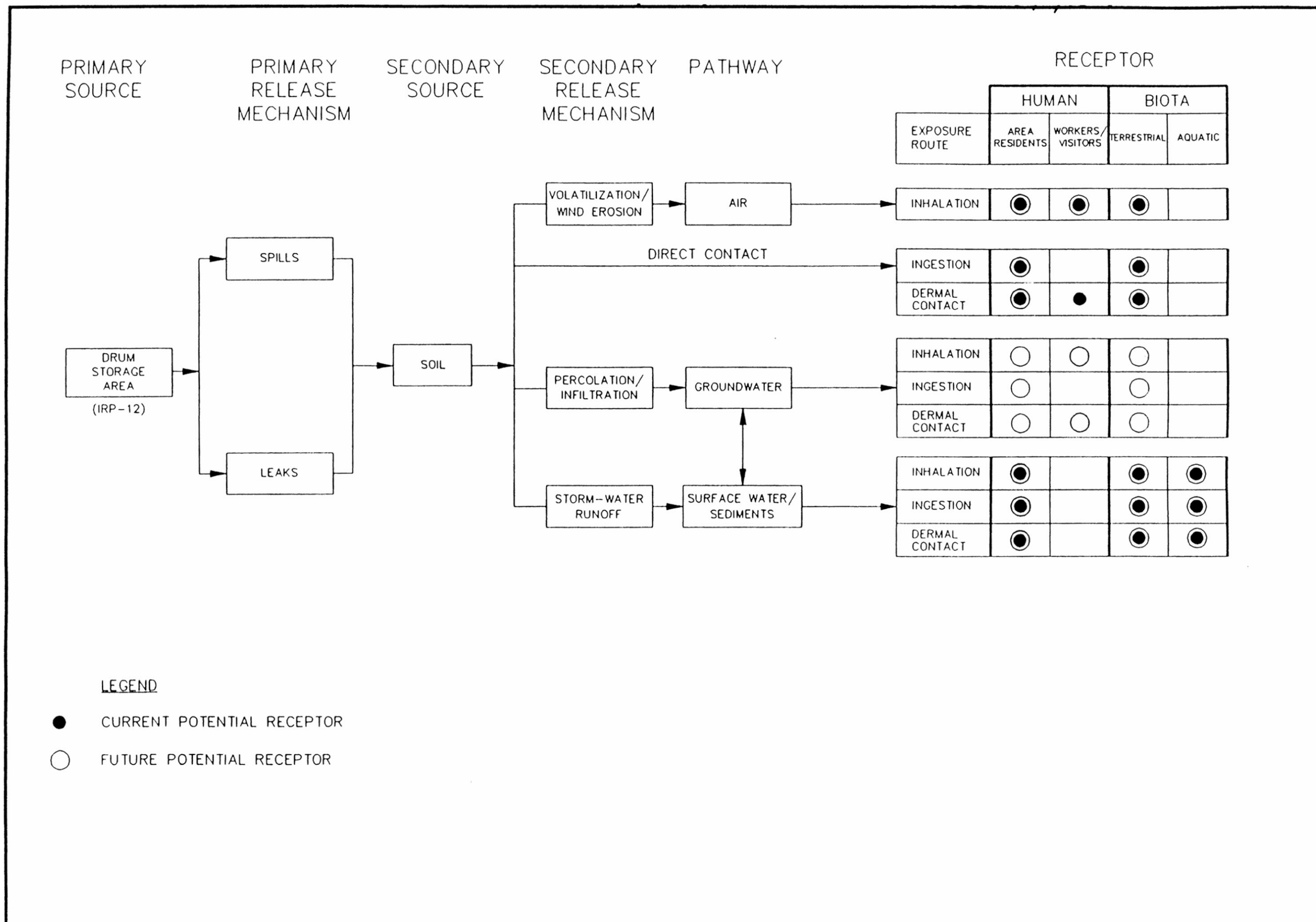


Exhibit 4
Initial Conceptual Site Model in Plan View



Adapted From: MCAS Tustin Remedial Investigation Report

Exhibit 5
Initial Exposure Conceptual Site Model



Adapted From: MCAS Tustin Remedial Investigation Report

Preparing Sampling and Measurement Strategies

The BRAC Cleanup Team designed a shallow soil sampling strategy for IRP-12 to detect hot spots based on statistical probabilities. First, they randomly placed a grid over the entire site based on 60-foot centers. Second, in the two areas where contamination was identified in the ESI (north of Building 90 and south of Building 20B), the grid was subdivided into 20-foot centers. Finally, in the area where contamination was suspected but not found during the ESI, project planners used a grid based on 30-foot centers. In addition, they decided to take two judgmental samples in the drainage ditch to better define the level of contamination detected in the ESI. Exhibit 6 presents a site map with the proposed sampling locations.

This sampling design satisfied two limits of uncertainty for risk assessment:

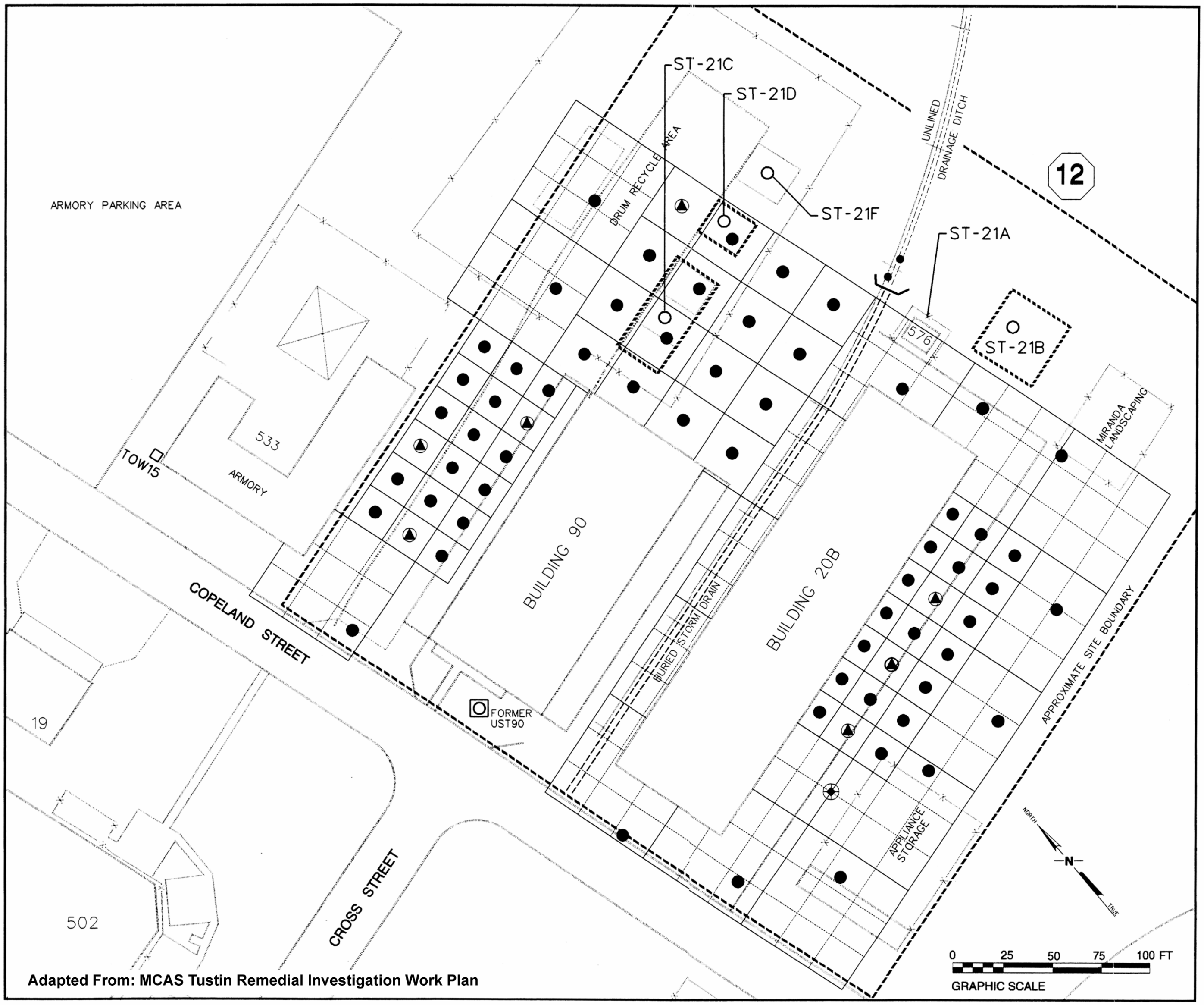
- The probability of declaring that the site is not posing any risk to human health, when in fact it is, will be 5 percent or lower; and
- The probability of characterizing the site as posing a threat to human health, when it does not, will be 20 percent or lower.

If on-site analysis indicated the initial sample taken between 1 and 2 feet bgs was contaminated, investigators would hand-auger the location to 5 feet bgs because of a base requirement to avoid damaging utilities. They then would use direct push (DP) equipment to take continuous cores to the first permeable zone (15 to 25 feet bgs). Unless the flame ionization detector (FID) or visual inspection by the geologist suggested a better sampling interval, samples would be taken at seven feet (estimated top of the water table), 12 feet bgs, and in the first permeable zone. Whenever soil samples from the first permeable zone demonstrated high volatile organic compound (VOC) levels, investigators would take groundwater samples with a driven sampling point (i.e., equipment for taking a one-time groundwater sample that is pushed to the sampling point, such as the HydroPunch™) for screening analysis.

If any groundwater samples were found to be contaminated, investigators would search for the source area and horizontal extent by sampling groundwater with DP equipment in upgradient and downgradient directions on 20-foot centers. After finding the source area, they would delineate the lateral extent of the plume by step-out sampling on an axis perpendicular to the groundwater flow direction.

Since one of the potential chemicals of concern (PCOCs) was capable of forming dense non-aqueous phase liquids (DNAPLs), the BRAC Cleanup Team recognized the need for sampling multiple permeable zones. Therefore, they sought sampling equipment that would provide the hydrogeologist with the flexibility of reaching the required sampling zones without posing a risk of dragging contamination into previously uncontaminated areas. At the same time the equipment would have to be capable of obtaining a quality groundwater sample in each permeable zone it encountered.

Exhibit 6
Initial Sampling Locations at IRP-12



Only after the extent of the plume had been fully defined would the Navy propose monitoring well locations and screening intervals to the regulatory agencies for their approval. This procedure would help ensure that each monitoring well provides useful information for long-term study of the contaminant plume(s). If the data indicated that a pump-and-treat system was a viable remedial option, then a hydrogeologist would complete an aquifer pumping test in the same mobilization as part of the feasibility study.

Selecting Appropriate Analytical Methods, Equipment, and Contractors

The first step the BRAC Cleanup Team used in selecting appropriate analytical methods for IRP-12 was identifying the PCOCs, from the historical information, and their associated risk concentrations, from chemical ARARs and "To Be Considered" guidance documents. Using these documents, the BRAC Cleanup Team determined that their FAMs needed to provide a detection limit of a least 5 μg/L for TCE, based on the federal MCL, and a total recoverable petroleum hydrocarbon (TRPH) detection limit of 10 mg/kg, based on the preliminary remediation goals for PAHs found in waste oils.

The review of historic site data revealed several items that helped streamline sample analysis. First, the site had obvious VOC contamination (i.e., fuels and halogenated solvents). Second, the risk drivers for cleanup in many cases were PAHs related to engine waste oils that had been disposed improperly. Third, metal concentrations that appeared to be above naturally occurring levels were always related to either VOCs (paint strippers) or waste oils. Consequently, any FAMs that could be used for VOCs and waste oils (PAHs) could also ensure that metal contamination would not be missed.

Based on this information the project team selected the following FAMs:

- A hand-held FID for VOC screening of soil samples;
- A gas chromatograph/photoionization detector (GC/PID) method (U.S. EPA, 1994b) with detection limits of 5 μg/L TCE in water and 25 to 50 μg/kg TCE in soil (as well as other VOCs); and
- A project-modified EPA Method 418.1 (infrared spectroscopy) with a method detection limit of 10 ppm for analysis of TRPH, which would be used as a surrogate for the presence of PAHs and metals in oils.

A throughput of 60 to 70 samples per day was expected with the GC/PID. EPA provided performance evaluation (PE) standards for both the on-site and off-site laboratories. All other VOCs that were detected by the instrument would require additional analysis for definitive identification.

The quality assurance project plan (QAPP) proposed confirmatory analyses on 10 to 15 percent of the field analytical data at an off-site laboratory. Two-thirds of these samples would be the most contaminated according to the on-site analysis, and one third would be non-detects. The type of analyses performed by the off-site laboratory also would vary depending upon what caused the sample to be sent. If a VOC was identified on-site, then VOCs and metals would be tested. If TRPH was identified on-site, then PAHs, PCBs, and metals would be requested. The one-third of confirmatory samples that were non-detects would be tested for all constituents. To accommodate the on-site instrumentation, a laboratory trailer with hood, sinks, and counter space was contracted for $2,900 per month.

To collect soil samples, a dual-tube DP rig was chosen (i.e., an outer casing is driven at the same time as an inner sampling tube). This procedure prevents the walls of a hole from sloughing as a sample is removed. The equipment provides continuous samples in 3-inch by 1.65-inch sleeves, and its production rate is six to seven 20-foot holes per 8-hour day.

For shallow groundwater sampling a drive-point sampler (i.e., HydroPunch™) was selected so that samples could be collected quickly without the expense of installing a complete monitoring well. Hollow stem auger equipment was selected for setting shallow to medium depth monitoring wells and well points, and a dual-tube air percussion rotary rig was selected for investigating the deep regional drinking water aquifer. The air rotary rig is faster than hollow stem augers and provides a continuous core while driving an outer casing as part of its normal drilling operation. The outer casing prevents cross contamination of different aquifer zones. The firm chosen to supply this equipment was large enough to be able to add and subtract drilling rigs with little advance notice. This feature provided added flexibility because it allowed for as little as one piece of equipment to be on site or as many as three hollow stem augers, one well development rig, and one dual tube air percussion rig, depending on project needs.

In sampling groundwater, the planning team proposed measuring pH, temperature, specific conductance, dissolved oxygen, redox, and turbidity with a flow-through cell. The cell provided continuous real-time measurement of these parameters that could be used for evaluating water quality as well as providing information on whether formation water was flowing through the cell. The real-time turbidity measurements were especially helpful in taking water samples for metals analysis.

Selection of additional contracts and arrangements included:

- A geophysics firm to perform utility clearance and to locate any subsurface anomalies that required further investigation;
- A survey team to provide reference points and well point location data;
- A fixed laboratory to perform off-site confirmatory analysis using methods published by EPA's Contract Laboratory Program and SW-846; and
- A data validation firm to validate off-site laboratory results.

The prime contractor provided oversight of the work with experienced personnel as it occurred.

Writing a Dynamic Work Plan

The contractor submitted a dynamic work plan containing a number of elements that made it different from a staged approach. These elements included the use of:

- On-site analysis of groundwater samples to locate monitoring wells;
- On-site field instruments for determining the extent of contamination;
- One type of organic detection as a surrogate for other organic and inorganic contaminants;
- Sampling decision trees that would be implemented if contamination was found during the initial preset sampling phase; and
- Flexible sampling and analysis planning that included contingencies for alternative methods if problems occurred.

During the review of the dynamic work plan, the regulatory agencies objected to the first four of these five elements. Items two and three were resolved when the contractor prepared an issue paper for the regulatory agencies showing that the field instruments could detect both VOCs and oil contaminants at levels of concern, and that the detection limits for these surrogates also would capture any metals or PAHs that were in the oil, or VOCs at concentrations of concern.

With items one and four, the state and EPA regulators were concerned that the on-site decision making would result in insufficient regulatory oversight. As a result, the work plan was amended to ensure full participation of the regulatory agencies in the decision-making process through the submission of weekly summaries for teleconference discussion followed by weekly progress meetings. In addition, if any serious problems arose during the week, a conference call would be scheduled. This arrangement satisfied the agencies' concerns and the plan was approved.

Conducting the Dynamic Field Activity

The field team was able to adjust the dynamic work plan before beginning the actual field work because IRP-12 was not the first site to be investigated. The major change resulting from their experience was to use the dual-tube DP rig to collect both groundwater and soil samples at the initial sampling locations, rather than the drive point sampler. The dual-tube DP rig had been shown to produce acceptable VOC sample results at other locations on MCAS Tustin. The drive point sampler was used only when groundwater was the only medium to be sampled or when a metals analysis was to be performed on the groundwater sample because of regulator concerns about potential turbidity levels.

Selection of Sampling Locations

The IRP-12 field work began with a utility clearance of the sampling locations through a geophysical survey of the site. Subsequently, two hand auger crews consisting of a geologist and technician began the shallow soil sampling at the statistically selected locations. The two hand-auger crews sampled up to 16 locations a day to depths of one to two feet bgs.

Refinement of Conceptual Site Model

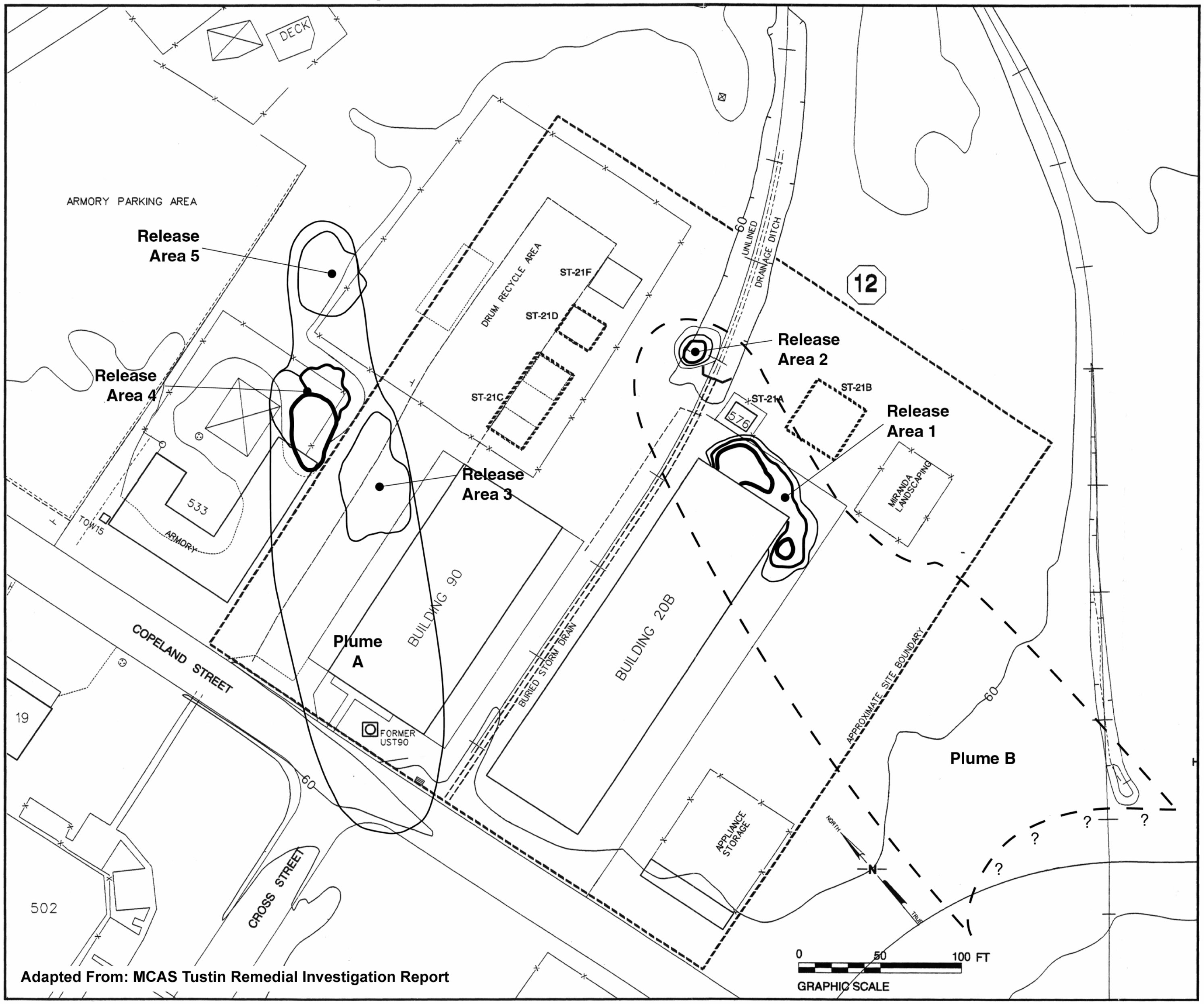
The initial sampling and analysis revealed one major surprise: significant TCE contamination outside the boundaries of all three storage areas, near Building 20B. In addition, the investigation confirmed the ESI findings of widespread—but low level—TRPH contamination in the shallow soil at Storage Area 1 adjacent to Building 90 (see Exhibit 2), and it found TCE contamination in the groundwater and shallow soil in the same area. In contrast to the findings of the ESI, however, the initial sampling did not find any TRPH in Storage Area 2 adjacent to Building 20B, while it did find widespread but low-level TRPH contamination in shallow soil at the Storage Area 3.

The investigators then initiated a second round of sampling with the dual-tube DP rig at sampling points that had shown signs of contamination following the decision tree outlined in the work plan. At these locations, continuous cores were collected from 5 feet bgs to the silty sand layer at about 20 feet bgs. In addition, groundwater samples were collected in the silty sand layer. This round of sampling delineated the source area of the contamination next to Building 20B. However, the groundwater underneath the clean, upgradient soil samples was contaminated, indicating the presence of an additional source area. Further sampling delineated a second source area about 50 feet outside of the initial sampling zone. Upgradient groundwater samples were clean, confirming that there was no additional source for the plume.

The investigation of the source area next to Building 90 followed a similar scenario. Shallow soil samples collected upgradient of the initially identified source area were "clean," however, the groundwater at these points had significant TCE concentrations. The subsequent soil sampling identified another source upgradient. Attempts to bound groundwater contamination upgradient failed a second time, and an additional source area was sought. By continuing to sample soil and groundwater in an upgradient direction, the fifth and final source area in IRP-12 was identified and delineated.

The completed source investigation showed shallow low-level (less than 200 ppm) TRPH contamination in Storage Areas 1 and 3 but insignificant contamination in Storage Area 2 (refer to Exhibit 2 for locations). It also found five TCE source areas that produced two shallow groundwater plumes, both continuing beyond the boundaries of the original IRP site. The resulting interim conceptual site model is presented in Exhibit 7. With the source areas identified, the dual-tube DP rig was used to continue the shallow plume delineation. The field

Exhibit 7
Interim Conceptual Site Model of IRP 12 TCE Contamination



team was able to define the shallow plumes within eight days with a total of 21 samples. This was accomplished by using only on-site laboratory results from water samples that were available within the time it took to decontaminate the equipment and move to a different location. Exhibit 8 presents the results of this phase of the investigation.

The next step was to determine how deep the TCE had migrated. This was accomplished by taking water samples in the outer casing of the dual-tube air percussion rig. This investigation demonstrated that the plume originating near Building 90 was confined to the first permeable zone, but that the larger plume, originating near Building 20B, had penetrated to a second permeable zone, within the shallow aquifer, between 42 to 53 feet bgs. This information was then integrated into the conceptual site model presented in Exhibit 9.

Completion of Field Program

In October 1995, the BRAC Cleanup Team examined the data delineating the two plumes and decided how to place the necessary number of monitoring wells efficiently. In all, only 14 monitoring wells were installed and developed, with the work being completed in November and December 1995. Since pump-and-treat was a viable option for aquifer remediation, two aquifer pumping tests were designed and conducted to aid in the feasibility study evaluation and future remedial design.

In December 1995 the Navy submitted a short summary of findings to the regulatory agencies. The summary presented all available data along with a discussion that indicated the nature and extent of contamination at the site had been characterized. In response, the regulators suggested that one more deep boring be placed in the central area of the larger plume to better define how far the plume in the second permeable zone had traveled. This was completed in January 1996 along with the first round of permanent groundwater monitoring well sampling.

Following monitoring well sampling, the field team performed a final quality assurance check on the existing data before equipment was demobilized. This review revealed a few data discrepancies, and the technical team leader ordered the field team to collect three additional soil samples. Furthermore, there appeared to be a gap in the soil characterization to the east of Building 533. To ensure that another source area did not exist at this location, the field team collected three shallow judgmental soil samples. All of these additional samples were collected in March 1996.

Over the life of the investigation, the effort was expanded from an initial 68 sampling points to 147. Of these, 60 were between 1 to 2 feet bgs, and 54 were taken in the first permeable zone (i.e., 15 to 25 feet bgs). Approximately 390 soil samples were screened by the on-site laboratory, and approximately 70 were sent off-site for some form of confirmatory analysis (i.e., VOCs and metals; or metals, PAHs, and PCBs). In general, the two sets of

Exhibit 8
Conceptual Model of Shallow Groundwater Plumes at IRP-12

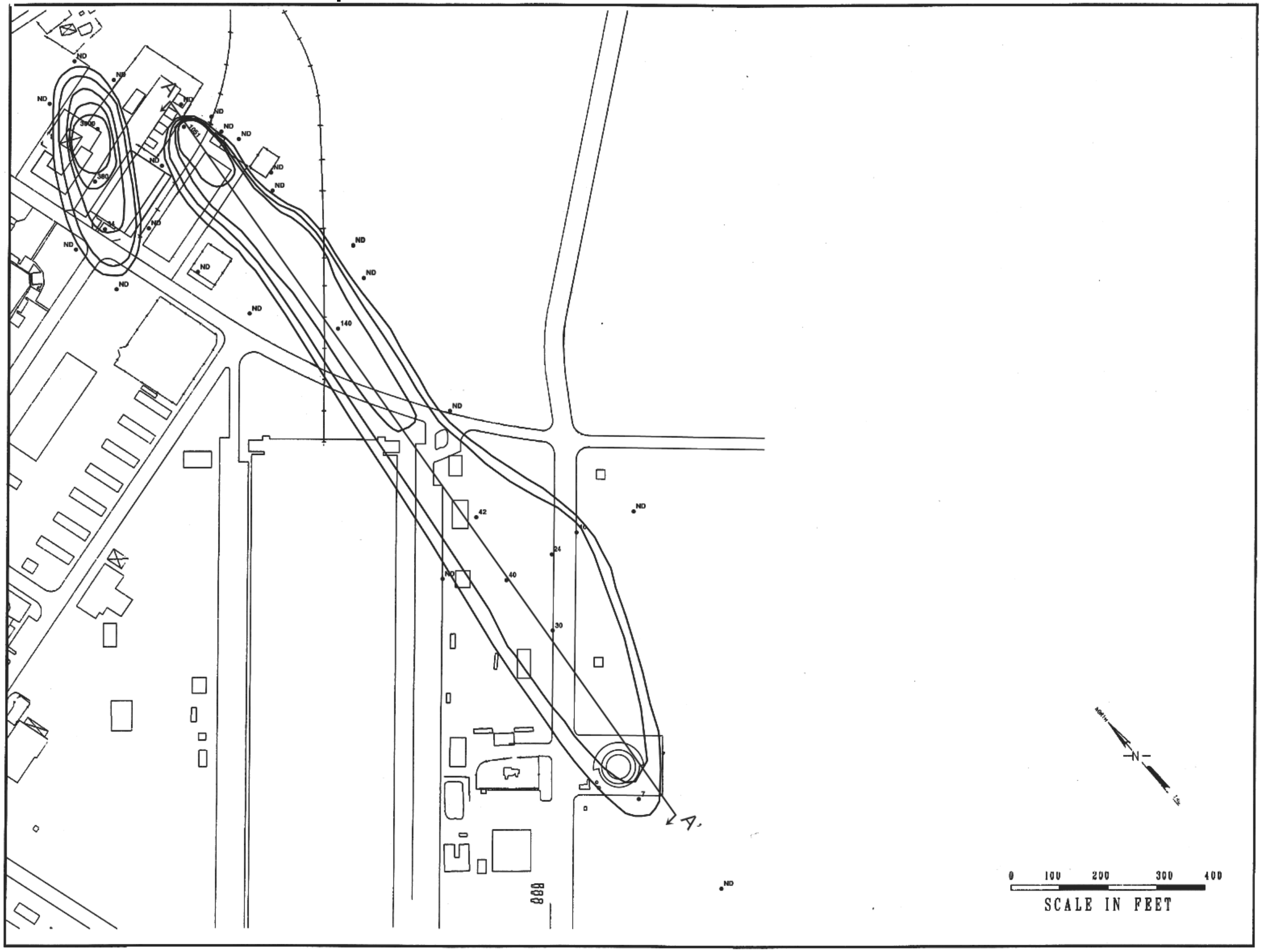
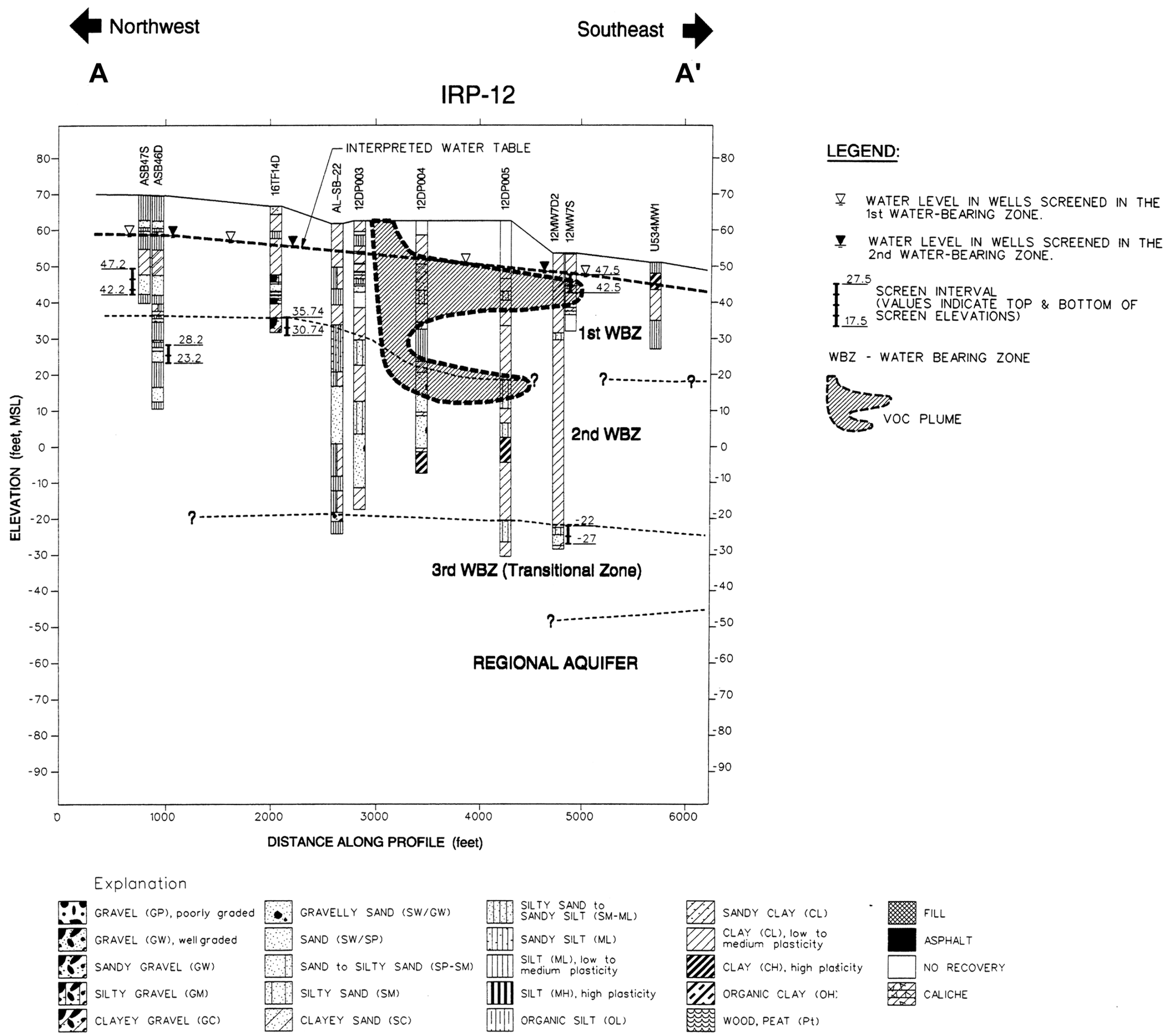


Exhibit 9
Conceptual Model of Larger Plume in Cross Section



results were in agreement. However, the on-site laboratory reported consistently higher concentrations for the soil samples than the off-site laboratory, probably due to the loss of VOCs during sample handling.

Approximately 110 groundwater samples were screened by the on-site laboratory of which 79 were split with the off-site laboratory for confirmation. The high number of off-site analyses was due primarily to the fact that a number of these groundwater samples were collected from the permanent monitoring wells that were installed after the completion of the dynamic field activity portion of the RI/FS. In addition, another group of samples could not be analyzed on-site because the on-site laboratory was not set up to perform analysis on metals in groundwater. The on-site analysis of groundwater samples was used primarily for identifying the presence of TCE for plume delineation. In this group, there were 69 samples that were analyzed on-site, 14 of which were sent off-site for confirmation. There was very good agreement between the results of these samples, with the off-site laboratory generally reporting slightly higher concentrations, perhaps due to more efficient purging capabilities of the off-site laboratory.

Writing a Final Report

The three major sections of the final report that are of interest to this case study included:

- Nature and extent of the contamination;
- Contaminant fate and transport;
- Human health risk assessment; and
- Data quality assessment.

Nature and Extent of Contamination

The soil and groundwater investigation discovered five TCE source areas that contributed to two groundwater plumes. The plume originating near Building 90 had three source areas and was confined to the first sandy zone in the shallow aquifer. It was approximately 125 feet wide and 400 feet long. The plume originating near Building 20B had two source areas and penetrated into a deeper sandy gravel layer within the shallow aquifer but did not reach the regional drinking water aquifer. It was approximately 150 to 300 feet wide and 1,500 feet long.

In addition, to the surprise of the BRAC Cleanup Team, Freon 113™ was detected in confirmatory laboratory results that arrived during the delineation of the plume originating at Building 20B. The results showed that the Freon 113™ plume was slightly smaller than, and within, the TCE plume, so they concluded that characterization of the TCE plume would also encompass the less hazardous Freon plume. No background information, nor any previous sampling, provided any indication that Freon 113™ was a potential contaminant of concern, and the selected instrumentation (GC/PID) was unable to detect it. However, in choosing the instrumentation, the investigation team had considered the possibility of not detecting potential chemicals of concern in the planning process. For this reason, a third of the samples sent to the off-site laboratory were on-site laboratory non-detects. A more complete discussion of this issue is provided in the "Lessons Learned" section that follows.

Contaminant Fate and Transport

With the help of MODFLOW (McDonald and Harbaugh, 1988) and MT3D (Zheng, 1990) modeling software, the BRAC Cleanup Team predicted that the two plumes in the first permeable zone would slowly migrate to the south and co-mingle through dispersion as they dilute. After 100 years, the model indicated that the plume may migrate off-base at a TCE concentration in the 10 to 20 µg/L range. The low-concentration TCE plume in the second permeable zone also was expected to migrate south and dilute. Because of the slightly upward groundwater gradient, none of the plumes were expected to reach the regional drinking water aquifer (approximately 100-120 feet bgs).

Human Health Risk Assessment

The potential risk drivers for the site at the beginning of the investigation were believed to be heavy metals (primarily arsenic, cadmium, chromium, and lead), PAHs found in waste oils, and TCE. The soil investigation found that the risk from metal and petroleum hydrocarbon contamination was negligible. TCE soil contamination was found in five general areas at concentrations below the state preliminary remediation goal for soil. However, given the depth to groundwater, these areas were considered secondary groundwater contamination sources and were candidates for remediation to prevent further degradation of the aquifer.

In addition, although TCE concentrations in groundwater were above MCLs, human exposure to the contaminants through drinking water was not considered a risk factor because the contaminated groundwater was not potable. The BRAC Cleanup Team came to this conclusion by noting that the concentration of total dissolved solids (TDS) was as high as 15,000 mg/L with manganese concentrations up to 2 mg/L in the shallow aquifer, and secondary drinking water standards for TDS are 500 mg/L and 0.05 mg/L for manganese. In addition, the aquifer was not appropriate for irrigation, not only because of the high TDS, but also because of the low transmissivity (84 gpd/ft). Furthermore, an aquifer pumping test using an agricultural supply well (3,000 gpm) screened in the underlying regional aquifer indicated that there was no hydraulic connection with the shallow aquifer.

In spite of these issues, the BRAC Cleanup Team decided remediation of the aquifer was appropriate for two reasons. First, California law requires groundwater remediation for all its aquifers unless treatment is proven to be technically infeasible. Second, the model of the plume indicated that it would eventually discharge to a nearby surface water and potentially threaten a neighboring wildlife refuge. Consequently, the RI recommended that remedial measures be evaluated for the groundwater at IRP-12.

Data Quality Assessment

In order to demonstrate that data collected at the site were adequate for decision making, the final report included a section on data quality assessment. This section examined whether investigators met the site performance criteria with regard to precision, accuracy, representativeness, completeness, and comparability (PARCC). Although the on-site GC and oil analyzer were used only for determining the extent of contamination, a comparison of the data generated was made with appropriate off-site results. Based on an agreement between the Navy and regulators, the following types of off-site laboratory data received full validation in accordance with EPA's Contract Laboratory Program National Functional Guidelines:

- All well-point samples;
- All PAH data;
- All hexavalent chromium data;
- Deep soil and water samples;
- 10 percent of VOCs;
- 10 percent of metals; and
- 10 percent of PCBs/pesticides.

All other off-site data was reviewed to ensure that it was reported adequately and consistently.

The results of the PARCC analysis stated:

- Precision: Precision for both laboratory and field duplicates was determined to be of acceptable quality. Outliers did not affect the overall conclusions of any of the investigations.

- Accuracy: Attainment of accuracy performance criteria was judged to be acceptable, with the exception of PAH analyses by the fixed laboratory with Method 8310. This finding was discovered early in the investigation and resulted in a formal project audit of the laboratory when complaints did not rectify the problem. The audit resulted in the dismissal of the chemist running the method.

- Representativeness: With the exception of only a few small anomalies the data were deemed to be representative. An analysis of these problems indicated they would not change any risk or remedial recommendations being made for the site.

- Completeness: Completeness generally is judged by the number of planned samples versus the number of actual samples taken that are useable. Since this program was dynamic, the number of planned samples was not specified at the beginning of the project. However, completeness can also be measured by the number of samples shipped for analysis (i.e., samples for which data are required) and number of useable results obtained. Under this modified definition, a completeness factor of 99 percent was achieved at all but one of the IRP sites (IRP 16 at 97 percent). IRP-12 was 99.6 percent complete.

- Comparison of On-Site and Off-Site Data: Because soil samples analyzed by the two laboratories were duplicates rather than splits, they could not be compared directly. Consequently, there was some disparity between the two laboratories. On the other hand, because groundwater samples tend to be more homogeneous, the data evaluated for the two laboratory groundwater data sets were largely comparable.

Estimated Cost and Time Savings

Although the field work for IRP-12 began in August 1995 and was completed in March 1996, the actual time spent on the site only totaled six weeks. The long period of time for the field work was not the result of staging the field activities, but rather from the integration of all dynamic field activities so that the problems at the base could be treated as a whole. This approach allowed for the free movement of equipment and personnel between locations. When the technical team leader reached a point where his evaluation of the on-site data indicated that subsequent activities should be discussed with the BRAC Cleanup Team, the field team would move to a new site. It should be noted here that had IRP-12 been the only site under investigation the review process would have been altered to allow for uninterrupted activities. The investigation often continued at the new location until another decision point was reached, at which time they moved back to the original site or on to a different location. Since the goal of the investigation was to characterize the contamination at the entire military base as quickly as possible, not just one location, equipment and personnel were not bound to a specific spot.

Although it is difficult to distinguish the resources required for only one location at this site, we have estimated that the cost of IRP-12 was $496,000, and that it would have taken a total of 10 months (including project planning and the writing of a final report). Although it is even more difficult to estimate the resources that would have been spent at the site had dynamic field activities not been conducted, we estimate that a staged approach could have cost $587,488 and would take approximately two years. This is based on the assumption that an accurate characterization would have required four mobilizations: the first for initial sampling, a second to install the first round of monitoring wells, a third to find the source areas outside the initial sampling area, and a fourth to delineate the contaminant plumes.

Each of these mobilizations would have resulted in extra time and cost associated with the preparation and review of iterative work plans as well as interim reports. This estimate does not include the administrative expenses EPA and the State of California would have incurred through regulatory review of multiple report and work plan iterations, nor does it include the additional time and money that is often required during the CERCLA remedial design and remedial action to refine the conceptual site model (the dynamic approach was able to completely characterize the site so there would have been no additional expense for this activity). Finally, incalculable but significant costs would have been incurred with the staged approach through the long-term expense of sampling and monitoring large numbers of wells that are ineffectively located. A summary of the cost and time comparison is presented in Exhibit 10, a detailed discussion of how they were calculated is available at http://www.epa.gov/superfund/programs/dfa/casestudies.

Exhibit 10
Dynamic Field Activity vs. Staged Investigation
Summary of Cost and Time Comparisons

Category		Dynamic		Staged Totals For All Phases	
		Cost	Time (weeks)	Cost	Time (weeks)
Work Plan Development		$64,920	14	$105,295	35
Field Activities	On-site Analysis	$40,140	6		
	Off-site Analysis	$107,920		$180,285	16-24
	Sampling Equipment Costs	$93,800		$62,288	6
	Prime Contractor's Field Support	$60,620		$44,310	
	Misc. Field Costs	$20,000		$20,000	
Report Writing		$109,200	24	$169,260	50
Grand Total		**$496,600**	**44**	**$587,488**	**110-118**

Lessons Learned

Because this RI/FS work was organized and proceeded differently than any investigation either the contractors, regulators, or Navy had previously been involved in, there were a number of lessons learned. Although there were no major problems caused by the new process used at this site, with experience, the investigation could have proceeded more smoothly and more resources could have been saved.

Off-Site Analytical Program Oversight

There were several problems that resulted from poor communication or insufficient oversight of the off-site analytical program. The first resulted from a failure to warn the off-site laboratory when a sample was highly contaminated. Although it was program policy to do so, there was no good system in place to ensure that the warning occurred. This communication problem resulted in analytical delays and associated QC difficulties, especially with highly contaminated samples analyzed by SW-846 method 8310.

Second, although the sampling and analysis plan limited the type of analysis that the off-site laboratory would conduct based on contaminants detected by the on-site laboratory, samples going to the off-site laboratory were generally analyzed for all constituents. This additional analysis was caused by a poorly trained shipping technician and a distracted site supervisor. The result, though not detrimental to the investigation, raised the cost at IRP-12 by about $10,000.

Finally, the number of non-detect samples sent to the off-site laboratory was much higher than the analytical plan had prescribed. Non-detects were supposed to represent a third of the samples shipped, but they actually represented approximately 45 percent. The cause for these excess analyses was that the QC program was ineffective in tracking the ratio. Although spot checks were performed by the technical team leader, these were not done on a sufficiently frequent basis to correct problems.

Unexpected Chemicals of Concern

The information in the PA and ESI provided no indication that Freon 113™ had ever been used, stored, or detected at MCAS Tustin. In addition, the field analytical equipment used during the investigation was not able to detect it. Investigators had considered the possibility of an unexpected chemical of concern being missed by the on-site instrumentation, so the work plan included a provision for sending one-third of non-detect samples to an off-site laboratory for confirmatory analysis. Although this provision was sufficient for delineating Freon 113™ in this instance, if an undetected chemical had formed a separate plume or been at the leading edge of a plume, there may have been a need to revisit the site because the confirmatory analysis did not arrive for four weeks. Consequently, this case study emphasizes the need for analytical plans to contain provisions that will enable detection of unsuspected contaminants. Provisions could include using quick turnaround confirmatory analysis at the beginning of an investigation phase (e.g., delineation of source areas, groundwater sampling) or having analytical equipment on site that can detect broad ranges of contaminants (e.g., GC with two detectors).

Flexible Work Planning

Flexible work planning was an important aspect of the investigation because it allowed efficient use of resources and enabled changes to be made in how equipment was used as new information was obtained. An example of this was in the groundwater sampling program. The initial investigation plan proposed that soil samples be taken by a dual-tube DP rig, and that groundwater samples be taken exclusively by driven sampling point equipment (i.e., HydroPunch™). However, investigators learned soon after the start of the sampling program that a bailer could be lowered through the outer casing of the DP rod to collect a groundwater sample. Although the sample was turbid and therefore not useful for metals analysis because of the potential to bias the results high, it was still useful for on-site screening of VOCs. By being able to make this sampling plan adjustment in the field, investigators were able to save considerable resources, and they were able to supply the on-site laboratory with many more groundwater samples than had been projected, thereby obtaining a higher density of site data that improved the certainty of their decisions.

Performance Evaluation Samples

Because the PE samples that were used by the on-site laboratory were developed for the Superfund Contact Laboratory Program, they contained a number of analytes that the on-site laboratory was not set up to identify. Although regulators still found the results acceptable, more useful data could have been obtained if the PE samples were specifically designed for contaminants and concentrations that were most important to the project. The Contract Laboratory Program, operated by the EPA Office of Emergency and Remedial Response, can now provide site specific PE samples.

Geophysics

Apart from the dynamic field activities at this site, the Navy hired a third party to conduct an extensive geophysical survey. However, the study was not helpful because the upper layer of soil contained large concentrations of clay, effectively eliminating the usefulness of some geophysical methods, and there were no clear breaks in the site stratigraphy, effectively eliminating the usefulness of many other geophysical methods. Since this basic stratigraphic information was available before implementing the geophysical survey, significant resources could have been saved if the investigators had reviewed the data before concluding that a complete geophysical investigation was an appropriate activity for this site. Consequently, the usefulness of geophysical methods should be viewed on a site-specific basis.

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